



Review

Barriers and Benefits of ICT Adoption in the Nigerian Construction Industry. A Comprehensive Literature Review

Taofeeq D. Moshood ^{1,*} , Gusman Nawanir ¹, Shahryar Sorooshian ² , Fatimah Mahmud ¹ and Adekunle Q. Adeleke ¹

¹ Faculty of Industrial Management, Universiti Malaysia Pahang, Gambang Pahang 26300, Malaysia; gusman@ump.edu.my (G.N.); fatimahm@ump.edu.my (F.M.); adekunle@ump.edu.my (A.Q.A.)

² Department of Business Administration, University of Gothenburg, 41314 Gothenburg, Sweden; sorooshian@gmail.com

* Correspondence: taofeeqmoshood@gmail.com

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Abstract: Information and Communication Technology (ICT) is seen as a way to enhance knowledge collection in the construction sector. Although the theoretical benefits of ICT implementation have been clarified, realizing such benefits is insufficient. This paper attempted a systematic analysis of the literature using ATLAS.ti 9 software to save, identify, and analyze this study's data. A total of 102 articles were actively reviewed, including 82 Scopus journals and 20 conference papers published from 2003 to 2020. In this article, from a construction industry point of view, the ICT adoption process is considered as an interaction between technology, task, and an individual from a construction industry perspective. While ICT is acknowledged as a source of aggressive gain by both practitioners and scholars, ICT's sole presence would definitely not guarantee achievement in the industry's ICT approval. Companies cannot grasp the full benefits of ICT, except that users are able to adopt the technology. Hence, the issues related to ICT adoption need to be examined.

Keywords: information technology (IT); information and communication technology (ICT); sustainability; construction industry (CI)

1. Introduction

Information and Communication Technology (ICT) is an extended term that is usually employed in place of Information Technology (IT) [1]. It describes an extensive industrial spectrum of services concerning information technology, information systems, computer science, e-business, and software engineering. It embraces both soft and hard skills in programming development and systems, together with interpersonal communication skills [2,3]. It is a sector that comprises the distribution of information technology, telecommunication products, manufacturing of information technology, maintenance, and communication system installation.

In the ICT sector, the opportunities that favored the de novo entry were the rapid technological advancements that started in the early 1980s [4]. Over the last few decades, these advancements have gradually spread across many countries, reflecting the ICT components' increasing export rate in the 1990s. Consequently, this growth accounted for a considerable proportion of the total trade in ICT products, including telecom equipment, semiconductors, office machines, and IT products. Currently, it is commonly seen that the use of ICT enhances the competitiveness of organizational enterprises [5].

2. Literature Review

In the construction industry (CI), the use of ICT, also referred to as information technology (IT), is becoming essential in fields of engineering, construction planning and control, cost control and financial planning, computer-aided facilities management, and others, offering a variety of opportunities for more productive and efficient project implementation within the sector [6]. ICT research in the construction sector has concentrated on the prevalence of ICT [5] and the contextual impact on its application; the authors of [7,8], from the point of view of developed nations such as the United States [9], Canada [10], and Sweden [11], explored this area. Many other reports on its use and impact on companies' success in the construction sector have been published [6,12–14] and project efficiency [15,16]. Despite this exhaustive study around continents, only a few studies were undertaken from the standpoint of developing nations, such as Nigeria. This research suggests that ICT work in developing countries in the building industry may theoretically deliver a variety of new insights. The reason is that what an organization could find to be major obstacles to the introduction and use of ICT in a developing country such as Nigeria may be markedly different from those in a developed economy such as the United Kingdom, where the ICT sector is already defined with clear regulatory structures and cultural constraints [6].

The planning and adoption of advanced, collective, and integrated information technologies are essential for the CI's sustainable improvement in the new era. The unindustrialized information technologies allow the CI great potential to improve the collective performance of management information systems in the project, engineering, and construction risk and project management [17,18]. In recent decades, the development of ICT has affected the construction industry. New technologies have made it easier for construction companies to manage and archive their data, and it is possible to rapidly move large volumes of data. A variety of technology-based approaches to enhancing the tracking of building materials have recently been proposed [7]. ICT has provided efficient collaboration methods for building companies, and the advent of new ICT tools has saved time and costs. The Internet serves as an essential database and medium for correspondence. Electronic records can minimize paperwork and increase precision and usability. However, during the introduction of ICT in their businesses, construction organizations face various barriers [5]. There are internal obstacles and external hurdles to the building industry's addition of ICT [8]. Identifying these challenges will allow decision-makers to turn issues into opportunities. In Nigeria, the obstacles to ICT acceptance in the building industry lack examination. This study clarifies the existing challenges and opportunities that the Nigerian construction industry faces in the ICT adoption process. Therefore, the background of promoting ICT in the Nigerian CI is explained in the following.

First, the construction method produces enormous volumes of information. The information varies from sketches that were created in the strategy and plane phase to various project descriptions that developed throughout the construction phase. Data are collected throughout the whole period until the completion of the structure. Therefore, the synthesis and supervision of construction information in Nigeria are essential due to the information's variety and strength [19–21]. Building project management requires the collection, review, and real-time transmission of information for the prompt disclosure of time, cost, range, and position variations from planned execution and appropriate decision-making for reacting to the obstacles, conflicts, and irregularities identified from the scheduled production [22]. However, with conventional communication instruments, project managers usually lack timely change management [23].

Second, the construction companies have a remarkably complicated, fractured, and unique combination of market relations and approach to deal with. Both construction phases involve the efficient exchange of fundamental knowledge and collaboration between different project partners, such as project managers, consultants, consultants, operators, engineers, vendors, and subcontractors. This will lead to issues with timing and technological gratified contact transmission [24,25]. The project is unique in its associated construction standard, location, and plan [6,26]. The coordination problem among the project crew members normally triggers project delays, expensive reworks, and development

failures in the Nigerian CI [6]. Conventional techniques in construction management cannot overcome any of those contact hurdles. In this situation, ICT is a catalyst for service productivity and a key enabler of efficient information management and networking systems by which the company can collaborate and manage deals with its clients, experts, and supply chain associates [27]. Especially where project crews are globally dispersed beyond internal borders or when broad nations are placed within domestic boundaries, ICT may be used to handle information successfully [22].

Third, by combining more complex development models, an increasing number of outsourced project suppliers, closely engineered fast-track design strategies, and an internationally competitive marketplace, the opportunity to execute effective projects on schedule and within targets is becoming a critical challenge [18,28]. Through the effective use of ICT to facilitate the knowledge management process amongst project teams, it is unlikely that there can be significant improvements to the distribution system by using conventional methods. In fact, the implementation of ICT has become imperative for the CI because of the prevailing circumstances in today's manufacturing world, such as globalization, extreme competition, and the need to retain exceptional efficiency standards to survive [29,30]. For example, the requirement for more effective project efficiency in construction firms around the globe has been applied to change two-dimensional, three-dimensional, and current BIM design procedures [31]. ICT's value has evolved from being a product and utility to becoming a critical tool for every company to attain market growth and profit. Besides this, the effect of ICT-based adjustment is seen in its efficiency, providing the sector with an active sustainable benefit [27,32].

In response to the above reasons, the CI is promoting the use of ICT in both construction organizations and projects. The planned implementation of ICT in the CI could be perceived as both protective and sensitive because customers and supply chain associates frequently rely on these instruments; therefore, failing to utilize these devices makes a firm unattractive [6,33].

3. Methodology

3.1. Literature Search

In this research, the database source from Google Scholar and Scopus is employed to report a wider variety of journals and conference proceedings through the Google Chrome operator. Additionally, keywords and search patterns were utilized to find a broader range of ICT adoption research by various organizational perspectives, particularly in the CI. When using Scopus, a more comprehensive search context can be performed to obtain a target outcome. In this research, five sets of keywords (ICT Adoption, ICT Sustainability, Information Technology, Construction Innovation, and Smart Technologies) were employed in Scopus [34]. This created a total of 52 documents. Fifty articles were also collected from Google Scholar and Scopus. To sum up, 102 articles were collected from both Google Scholar and Scopus as the initial selection administered from February to June 2020.

An assortment of articles was selected since our study focus was on ICT adoption in the CI. The papers that were not focused on ICT adoption, idea boards, and the building were eliminated from our gathered literature. After this separation method, search results through Google Scholar and Scopus were narrowed down to around 42 and 44 papers, respectively. Finally, after discharging the overhung articles from both Google Scholar and Scopus, a total of 86 items were utilized in this research. The required mathematical information is shown in Figure 1.

The use of ATLAS.ti 9 software (quotation, family, and network) jargon would probably mean nothing to someone who is unfamiliar with the program. Paulus and Bennett [35] used and described software terminology, in comparison, to encourage readers to understand what was happening. In this summary, the researchers described the methodological methodology, program, and version and what characteristics (quotes, codes, and system hierarchy with memos) were used for the study. The meaning of quotes and the relationships between quotes and codes have been explicitly articulated. The researcher briefly explained to readers how the software was used, which could help to educate

This requires the elimination of materials in accordance with the research field and background or framework [36]. Usually, the data are reviewed and synthesized in terms of research features, nature, and research conclusions.

The software package of ATLAS.ti 9 software is appropriated in this research to save, classify, and interpret the evidence for this research. It comprises five components for the research review: (1) Purpose: This study intends to contribute insights into the modern development and ultimate potential of ICT adoption in the CI. (2) Concentration: This study concerns research characteristics (i.e., aims, techniques, sustainability, outputs) of ICT adoption in the CI. (3) Viewpoint: This analysis contains a neutral view on the articles under review. (4) Design: This article presents a conceptual framework first, before compiling the findings. (5) Coverage: The coverage of the literature is extensive [34].

By using the ATLAS.ti 9 software, the auto-code concept was initially used to identify and mark all aspects of the information organization for which ATLAS.ti 9 software was implemented as quotations for the primary stage of analysis. These quotations were arranged into a separate record for appraisal, and the quotes were regularly analyzed in conjunction with the study process. Driven by the study subject, all papers have been read several times and clarified to recognize repetitive themes and ideas [35].

Data analysis: After the coding system was developed, the main investigator had a clear description of the data. The codes used to convert and read data several times were optimized. The next step was to group codes into a cohesive pattern with respect to the study question. It is like a plot, where the theme is made up of a part of the plot. To review the case study figures and to sum up more in seven fields, twenty-three code groups were developed to provide initial ideas for the topics (Figure 1). The codes around the working issue were addressed over the course of the development of the theme in Figure 1. This was supported by the ATLAS.ti 9 network feature. Codes relating to ICT adoption, ICT sustainability, adoption of individuals, organization adoption, and construction innovation were built into a network linked with each other. This is not an automatic method. The software creates no connections and does not identify the links. The software gives the researcher only space for conceptual thinking. This happens when network nodes are organized—links are established and named. For instance, the network above (Figure 1) shows that ICT adoption practices are either relevant for individual adoption, organization adoption, or electronic data interchange (EDI). Figure 1 displays the information needed to access the mathematical framework.

3.2. Literature Consideration

The collected materials were designed to achieve three kinds of reports. (1) Overall report: to describe the literature evaluation's overall aim, the received articles are initially explained by their study backgrounds. (2) Comprehensive description: The principal emphasis of this research is on ICT adoption research for the CI, and the received articles are distributed by 14 keywords as discussed above. A detailed report on the received items is produced by their relationships, such as the research objectives, techniques, productivities, importance of technology utilized (i.e., innovation in construction, organizational adoption, individual perspectives, BIM innovation, ICT adoption, ICT sustainability, imitation tools, and examination components). (3) Lastly, the interaction review is a further step by which ICT adoption research for integrated design is considered through a review of multiple papers. Furthermore, a discussion of other possibilities, such as the difficulty of adopting ICT in the CI, its benefits, and ICT's sustainability, is presented below [34].

4. Adoption of ICT in the Nigerian Construction Industry

ICT adoption occurs in various fields, including the construction, industry, community, and private domains [41]. This review mainly focuses on the construction industry (organizational level and individual level) of the adoption, which is located in the construction sector and private domain. The construction industry domain focuses on the macro-level of the process in which new technology

is adopted. The community domain relates to the social practice in which the possible adopters are discovered. Ultimately, the private domain uses micro-level analysis to understand the individual-level procedure [42,43]. As a scale differs, the perspectives on new technology adoption under these domains vary significantly from each other. Each point-of-view offers a specific “lens” to assess how a circumstance (e.g., technological difficulty, etc.) interacts with the adoption of modern technology. These views are shaped by different benefits, rules, and standards of given fields of actions and thoughts [41]. The symbolic meaning of the term “adoption” is presented by Hua Yuanguan [30], “Making full use of a new idea as the best course of action available.” The author further claims that innovation adoption consists of a series of complex and contingent decisions. Typically, various factors are interrelated in the transfer process. Therefore, analyses of innovation adoption should (and usually do) take into consideration more than a single act. As a result, the process of innovation adoption in an organization has been divided into phases in previous studies [42,44].

Hua Yuanguan [30] put forward an information technology implementation model that contains six steps, particularly investment, organizational adoption, reutilization, acceptance and adoption, adaptation, and distillation. The outcomes of each stage are described as follows: (1) Initiation: an IT solution is found to match the specific demands of the organization; (2) Adoption: investment decisions are made by the organization to accommodate the implementation effort; (3) Adaptation: the IT application becomes accessible to end-users in the organization and is adapted to the organizational context; (4) Acceptance: the implementation of the technology is employed in the professional activities of the organization; (5) Reutilization: the organization’s governance systems are accustomed to accounting for the IT application and thus would not treat it as something out of the routine any longer; (6) Infusion: the IT application could realize its full potential within the organization.

According to MacVaugh and Schiavone [41], the adoption process is a series of phases that exist in an individual’s mind (possible adopter of a modernization) before eventually adopting a new product, concept, or service. The author describes the adoption process as the mechanism by which a person or other decision-making entity shifts from first awareness of innovation to developing an attitude towards innovation, a decision to accept or reject, to adopting the new concept, and verifying this decision [45]. Therefore, five stages are necessary for adopting ICT, namely awareness of facts, opinion, commitment, implementation, and certification [30,46]. Initially, at the level of understanding or intelligence, a person becomes aware of emerging technologies; then, he starts to think about whether or not to accept innovation in the stage of persuasion; the stage of judgment is where the individual considers possible advantages and drawbacks and takes the final decision on refusal or adoption; at the stage of implementation, a subset of technologies is implemented.

The research above explains the ICT adoption process from the perspective of the organization. However, the organizational adoption decision and implementation are only the beginning of the whole adoption process. The eventual success of it is more dependent on continued usage by users of the technology. Giotopoulos et al. [47] illustrated the key processes from the organizational adoption decision regarding ICT to individual adoption by users. In the beginning, managers devise objectives to improve their industry in some aspect, match their goals with available technology solutions, and select the initial adoption choice [48,49]. Once the fundamental adoption choice is made, the management team proceed to promote subsequent adoption by three fundamentally different paths: (1) Use coercive control and the requirement for progress to be implemented at once in the organization; (2) Promote the required structures and barriers for end-users to incorporate innovative technologies so that the transition will be made accessible voluntarily; or (3) Identify particular experimental programs within the construction industry, pay attention to the procedures and outcomes that are taking place, and determine whether to introduce the innovation. Figures 2 and 3 demonstrate the mechanism of ICT acceptance from the organization level to the individual level.

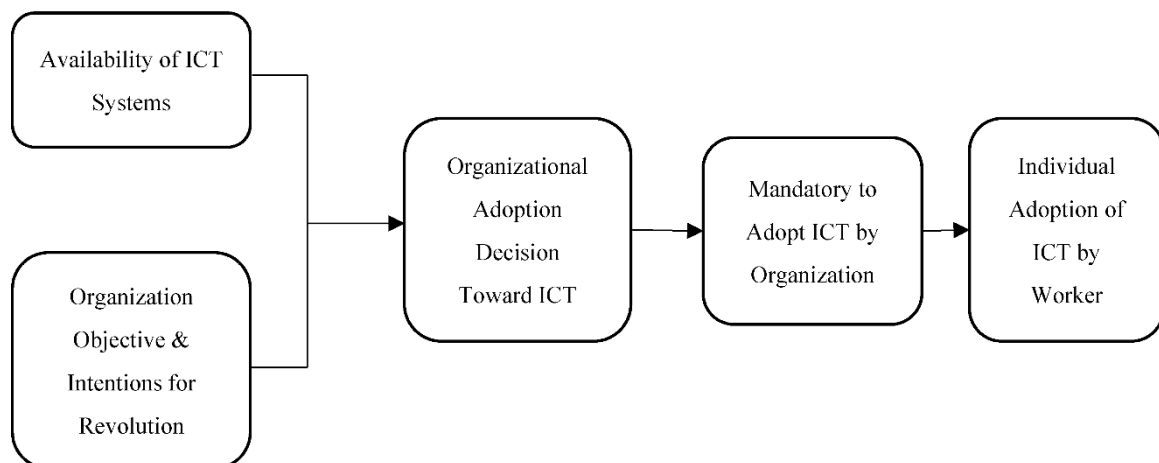


Figure 2. Organization adoption to individual adoption in the construction industry.

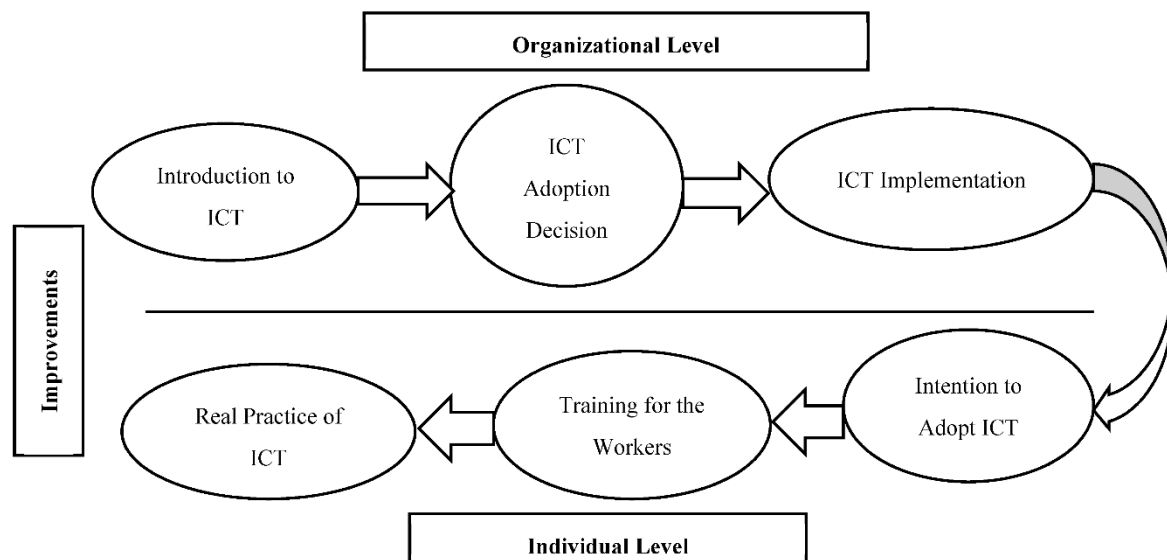


Figure 3. Multilevel of ICT adoption in the construction industry.

The adoption process also takes place through two stages. A proposal at the organization level introduces the product and requires acceptance by individual users or real implementation. The completion of the organizational decision-making process is only the beginning of the application. A successful combination of a new ICT with an organization depends more on users' continued usage of the technology than on its initial adoption because infrequent or ineffective utilization of the ICT may incur unexpected costs and result in a waste of resources in developing the ICT. Figures 2 and 3 show the ICT adoption process from the organizational level to the individual level.

Organizational-level ICT adoption is only the first step of ICT adoption. The transition from the conceptual benefits of an ICT to organizational performance improvements is realizable only by acceptance by target users because technology tools need to be effectively incorporated in the working process of an organization to yield benefits. Hence, it is also essential to examine the acceptance of technology within organizations. There are several influential models of an individual's adoption and use of ICT—for example, the technology acceptance model [50], the theory of planned behavior [51], and the unified theory of acceptance and use of technology [52]. The similarity between these models is that they all attempt to predict people's intentions and behavior to adopt the technology. In these models, the intention to adopt ICT and actual ICT usage are two well-established constructs to describe

individual ICT adoption. Therefore, the research on ICT adoption at the individual level focuses on an individual's behavioral intention and actual usage of technology [49].

Behavioral purposes are orders provided by people to act in certain ways [51]. They are the choices which people make to conduct certain acts. In psychological terminology, behavioral intent implies the desire of an individual to execute a behavior. Griffith, Northcraft, & Fuller [53] suggest that utilization is an operation containing three elements: (1) the individual, i.e., the person using the IS (Information Systems), (2) the system, i.e., the item being used, and (3) the mission, i.e., the role being carried out. Thus, the individual system user may be described as using one or more system features by an individual user to perform a task. Recognizing that people's usage of the Information System derives its benefit in the stage after the organizational adoption (i.e., the post-adoptive stage), researchers in IS began to devote substantial effort to understanding individuals' behavior regarding the system used in this stage [49,54]. The growing focus on post-adoptive system use is one of the most favorable developments in recent IS studies, known as ICT usage, ICT continuance, and post-adoptive ICT usage [55].

Contrary to the continued use of technology, non-use of technology also happens at the post-adoption stage in various forms. Rivard & Lapointe [56] pose an explanation of the mechanism of user resistance. When a system is introduced, users in a group will first consider its features, along with the organizational-level initial conditions and the interaction between them, and generate an evaluation of the system accordingly. Then, they assess the consequences of its use and take resistance behaviors if expected consequences are threatening. Satchell & Dourish [57] identify six types of non-use: lagging recognition, aggressive protest, dissatisfaction, impoverishment, displacement, and disinterest. When research into non-use advances, researchers learn that not all resistance is damaging.

Bagayogo, Beaudry, & Lapointe [58] propose that when ICT deployment fails to align with the objectives of the organization, conforming ICT-related behaviors produce unwanted detrimental impacts even when connected to users' adoption. By comparison, non-conforming ICT-related activities yield beneficial outcomes even though they are correlated with consumers' resistance. Rivard & Lapointe [56] claim that user resistance can function as a signal of problems with the technology or its effects, which will potentially lead to organizational disruption. Therefore, the implementer's response to user resistance is critical to the success of the ICT implementation. In addition to non-use, some researchers pay special attention to IS avoidance. Kane & Labianca [59] associate IS avoidance behavior with workers who need the system but deliberately choose to avoid it. Their study suggests that group members are affected by the system avoidance of others, even when they are unconscious of the particular individual who is performing the avoiding behavior.

Users may revise their use of ICT features during the post-adoption stage. Sun [60] developed the concept of adaptive system use to describe users' adaptations of system use and claimed that specific triggers cause people's revision of their use of system features under the impact of contextual factors. The empirical result shows that novel situations and discrepancies are significant factors leading to system use adaptation. Meanwhile, deliberate initiatives do not have a substantial effect on adaptations of system use [30]. In summary, this section explains the ICT adoption process from the organizational level to the individual level. Major theoretical models on ICT adoption, together with empirical findings on the factors that will influence ICT adoption, will be reviewed in the next section [46].

5. Types of ICT to Be Adopted

The current literature comprises a description of ICTs that are active in the CI. As is stated in the introduction, this research mainly focuses on three types of ICT—electronic data interchange/electronic data management method (EDI and EDMS), web-based management method, and building information modeling (BIM)—because the company-wide information system will have a more substantial influence on organization culture and people's behavior regarding stand-alone technology.

5.1. Web-Based Management System

From the very beginning of ICT use for the project, the benefit of web technologies in construction companies can be calculated. The web-based management framework is also used as an instrument for linking and obtaining multiple knowledge sets. There are different types of systems, such as a web-based decision support system, a web-based project management system, a shared online arrangement update, a web-based knowledge management system, and a management framework [45,61]. Web-based management systems are expected as remedial solutions to enhance communications in construction projects while improving the productivity, efficiency, and quality of products. The method requires the transferring and processing of the project correlated data and dispersed project members to be linked in electronic bases with the project members [62]. The use of web technology is proposed to have the benefits of bringing efficient collaboration, coordination, and communication, and decision-making methods [48,61]. Stewart and Mohamed [63] suggested that a web-based project management system could be evaluated from five perspectives, including improvement to operational processes, obtaining profits on construction projects, achieving planned goals, increasing satisfaction with the IT portfolio, and meeting the needs of the user [46].

Academics and practitioners anticipate that web-based project management systems could enhance and revolutionize the way in which construction-related organizations conduct business. However, the absence of a sufficient understanding of how to implement web-based project management systems resulted in widespread adoption, and effective use of the system failed to meet expectations. Dossick and Sakagami [64] recommend three critical strategies for successfully implementing a web-based project management system, including assigning a leader for the project, enforcing utilization with contract specifications, and training personnel by showing the benefits of usage of the web-based project management system.

Usually, the management of a building project involves a balance between the conflicting project constraints, including, but not limited to, scope, efficiency, scheduling, expenditure, capital, and risk [46]. In real estate development building projects, a project's work scope is typically specified during the planning phase. After the tendering period, the project duration, expense, and quality criteria are specified in the contract papers. The project managers of both the contractor and the developer must accomplish the built facilities to ensure the performance of project delivery in order to be appropriate to the specified standard, within the timeframe and the budgeted costs. Different services, including supplies, tools, and financial support and, in particular, personnel and skills, have to be given during the building period. Benefits management and contingency management are also relevant during the whole process.

5.2. Electronic Data Interchange (EDI) and Electronic Data Management System (EDMS)

Electronic data interchange (EDI) or electronic data management system (EDMS) is a unified tool for data exchange between various computer networks or computer systems [61]. EDI and EDMS are built to facilitate improved collaboration and communication in the CI. The core functionalities of electronic EDMS include record control, modify management, submittals, transmittals, and demands for information [65]. Agdas et al. [66] claim that EDI and EDMS solutions can add strategic advantages to a firm through automation, streamlined communication, and waste reduction, thus improving its competitiveness. The use of EDI and EDMS as instruments in building indispensable and responsive supply chains will reduce administrative efforts, accelerate data processing time, reduce error data, and eliminate data keying [48,67,68]. Figure 4 shows the benefits of electronic data interchange.

EDI studies propose that standardization is a major barrier to the successful adoption and diffusion of EDI systems in AEC (Architecture, Engineering and Construction) organizations [66]. The EDMS system usage is found to be lower than expected according to the planned system structure. Kähkönen and Rannisto [65] find that many folders in EDMS are seldom used or totally unused. In addition to this, some users have created extra folders to meet their own needs, which makes an

EDMS more complicated and more difficult to use. Therefore, they suggest that flexibility should be improved, and smart features need to be added for an EDMS system to achieve better ease of use.

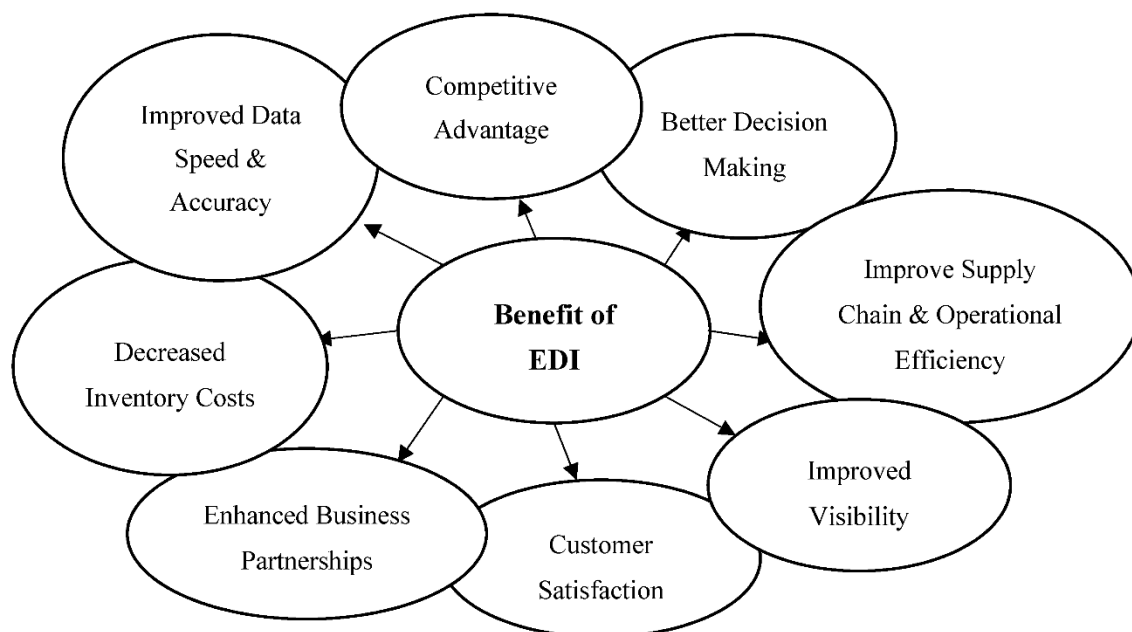


Figure 4. The benefits of electronic data interchange.

Shared access to information, standardized ways to scan for data, version control, the ability to read and use content without access to the program used to construct it, etc., are among the benefits of such programs. In other words, the structures provide a forum to keep all the document-based knowledge that is communicated in a building project in good order. This provides a tremendous opportunity to make the overall process more effective. One of the building industry's problems is its information-intensive project format, with new partner constellations for each new project. In the building industry, there have been very few earlier reports of the implementation of EDM. Agdas et al. [66] discussed the fact that in a project, the participants of a device should not be viewed as one single group but rather as consisting of multiple groups with various attitudes and abilities. The problem with an EDM system is that efficient usage allows both of them to implement the framework concurrently. A variety of factors influencing the effectiveness or failure of such schemes have been defined by Kähkönen and Rannisto [65]. In broad and complicated building projects, Hjelt and Björk [69] examined the implementation and use of a common method and, in particular, shifts in the behaviors of various groups of users after they began using the method.

5.3. Building Information Model

The building information model, or BIM, has attracted growing interest from both academics and practitioners as one of the most advanced innovations of recent years. There is, however, no consensus on BIM's interpretation. Aranda-Mena et al. [70] argue that, for some, BIM is a software application; for others, it is a mechanism for the design and analysis of building information; for others, it is a wholly novel method to the discipline and development of the profession that includes the introduction of new strategies, contracts, and partnerships between project stakeholders. Succar and Kassem [71] describe BIM as a collection of interacting structures, procedures, and technologies, creating a framework during the building's life cycle to handle the critical building design and project data in digital format. BIM functions as a shared network of information for a project and plays a supporting role in decision-making during its life cycle. Different stakeholders can have varying views on BIM roles. For example, architects tend to use BIM to improve productivity, coordination, and business

transactions, while contractors are more likely to schedule, estimate, and carry out processing [48,72]. Figure 5 shows the benefits of the building information model.

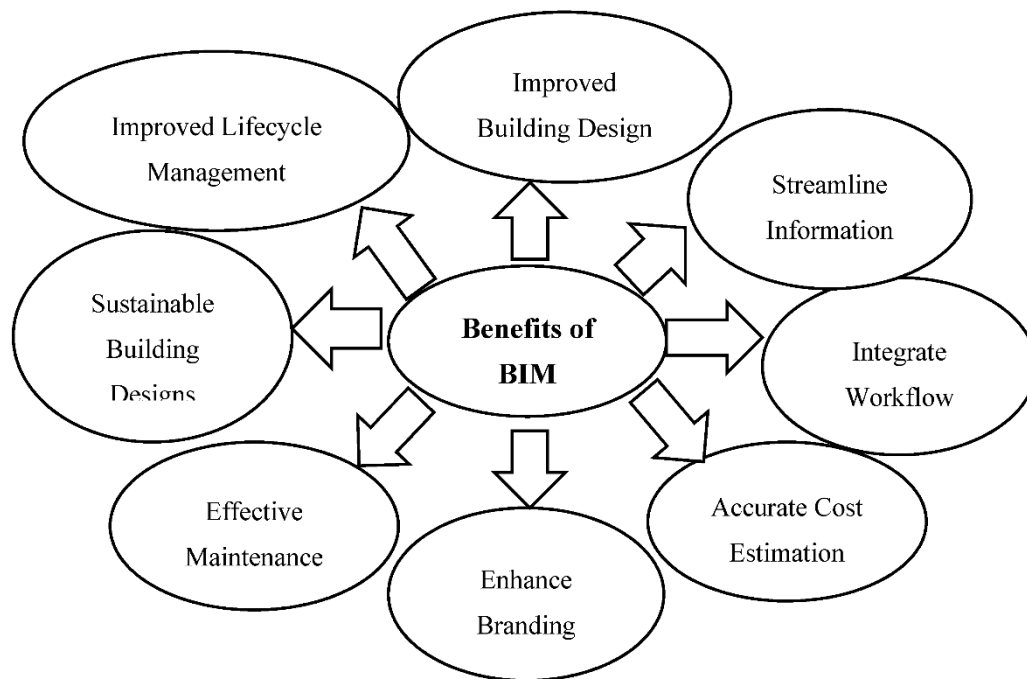


Figure 5. The benefits of the building information model.

The introduction of building information modeling (BIM) has demonstrated a great deal of promise for building planning, construction, and maintenance to increase performance. BIM was described by Yan and Damian [73] as a powerful range of design management tools that have considerable advantages over the entire life cycle of the building, particularly in planning, construction, and facility management. It is a forum that enables cooperation and enhancement of project performance between project stakeholders. Over the years, the BIM problem has acquired universal attention among all building industry stakeholders worldwide. By maintaining good coordination and cooperation between all project stakeholders from the beginning to the end of construction projects, BIM is seen as a catalyst for the building industry to increase its competitiveness. Succar and Kassem [71] found that many architecture and development organizations in numerous parts of the world are heading toward BIM adoption in their activities. Arayici et al. [73] reported that several pilot and live projects in Finland, Sweden, Norway, Germany, France, Singapore, the United Kingdom, and Australia have been completed and registered in the recent past, showing the potential to use BIM in the construction phase. Yan and Damian [73] concluded that not all industries are involved in its implementation, but with growing initiatives by researchers and market leaders, the future of BIM technology in the industry still looks promising. BIM's advocates have proposed that some advantages include improving and changing the design and development process, combining building designs, parts, graphics, and descriptions in ways that are not feasible in 2D CAD, providing parallel knowledge on efficiency and economic aspects of development, among others. This new technology has now demonstrated its ability to sanitize the building industry with increased efficiencies and teamwork capabilities from its conventional and fractured ways of functioning [73].

By using BIM in the preconstruction phase, it could increase design effectiveness by executing clash discovery and clash analysis; for scheduling, it could enable the project manager and contractor to track progress against logistics and timelines established while making the work sequence, equipment, and materials observable; also, it could allow generation of takeoffs, counts, and measurements by forming a three-dimensional project model and making specific estimation possible [30,48].

Furthermore, in the construction phase, BIM enables the presentation of the construction method, comprising entrance and exit roads, traffic issues, site materials, and types of machinery; it enhances cost regulation by providing more accurate tracking of cash flow; and it enables real-time work tracking, quicker resource movement, and more useful site supervision. Researchers point out that it is beneficial to adopt BIM at the early stage of the project.

6. Difficulties of ICT Adoption in the Nigerian Construction Industry

ICT utilization in construction companies is comparatively low compared to aerospace companies and automotive companies [74]. The construction companies in Nigeria are still in the relatively early stage of adopting ICT and remain behind other industries [75]. Many construction industries in Nigeria still depend on hand-operated methods for successful communication, such as emails, phones, and faxes. Users' resistance to corporate ICT applications remains a problem in the CI [68,76]. Although many construction organizations invest a lot in ICT and try to obtain ICT adoption advantages, the benefits may be restricted if fewer people embrace and utilize ICT because ICT achievement demands a significant mass of adopters to gain adequate communication and information interchange advantages [68,77]. An organization may spend on ICT practices while workers still communicate through the telephone and on paper. As a result, possible communication advantages of ICT may not be sufficiently realized. If the organization operates with both hardcopy and electronic data, it will lose potential productivity gains. As a result, even though some ICT projects are technically completed, the desired benefits are not realized. Unsuccessful ICT implementation in the CI is not rare [48,78].

Transitioning from a paper-based to an utterly automated setting demands users to embrace and adopt ICT quickly. Peansupap and Walker [26] claim that while several construction industries try to obtain ICT employment advantages, these may be limited when fewer people adopt and utilize ICT because this needs user approval. Even with full ICT approval, users will see it as being impossible to communicate electronically with co-workers who bypass the use of ICT. Therefore, the industry can lose possible productivity increases by working with both hardcopy and automated data [76]. Jacobsson et al. [79] find that the workers observed that further improvement of ICT practices would enhance the company's competitiveness. Still, on the other hand, they did not aspire to develop their application of ICT. Ding et al. [80] observe that in China, the process of BIM adoption among architect professionals differs meaningfully. An efficient BIM adoption approach should rely on the critical factors that impact architects' purpose of utilizing BIM. Brewer and Gajendram [81] observe that members of the temporary project organization are skeptical about the benefits of the project ICT and disinclined to engage; thus, their consequent behavior results in an overall state of ICT fragmentation. Gajendran and Brewer [82] further find that differentiation results in impaired e-business activity.

In summary, while the theoretical benefits of ICT adoption have been shown, the realization of these advantages remains minimal in reality. The critical problem lies in the aversion of users to ICT adoption, for it is the actual ICT user who eventually uses ICT resources to optimize work processes. In recent years, the impact of the current economic slowdown needs to be balanced by organizational and capital resources, which in turn involves a thorough optimization of ICT resources, leading to a "more improved for more limited" outcome [83]. Adoption activity by persons plays a major role in ensuring ICT adoption. Therefore, creating a system for understanding the influencing factors of ICT adoption is essential [48].

7. Sustainability of ICT Adoption

In science, "Sustainability" and "Sustainable Growth" are used reciprocally to describe the relationship between natural environments and human existence. The concept was created out of such a concern for growth trends and social activity production. It developed around the understanding that infinite development in a world with finite limits and capital is unlikely [38].

Hosseini et al. [62] found that ICT allowed access to transparent information, strengthened transparency, increased data quality, automation and coordination of operations, enhanced agility,

and provided insights into better decision-making. ICT is believed to have great potential for promoting sustainable growth in all construction and manufacturing operations [24,38]. Several fields of applied research have arisen to connect these two ICT realms with sustainability. This include environmental information science, in which ICT approaches to information retrieval are paired with environmental management science. Computational sustainability uses informatics, mathematics, and statistics tools to balance the demands of the climate, economy, and culture. The field of sustainable HCI is a sub-set of human–computer interaction (HCI), which brings human-technological experiences to sustainability practices. The emphasis, however, on the use of ICT to promote sustainability [38] is comparable to sustainable HCI. The premise of sustainability in ICT claims that the transformative power of ICT can be used to improve sustainability in any category of development.

The goal of ICT sustainable growth is to reduce the use of resources and energy by a commodity over a life cycle in order to improve its sustainability. However, ICT sustainability is intended to develop, allow, and promote sustainable development and consumption patterns through ICT. The key focus of ICT sustainability in operational terms lies in the use of ICT to encourage healthy lifestyles of goods such as the production of sustainable goods and waste reduction. Sustainability in ICT also targets efficient development processes by applying simulation ICT, pro-cessing space data, creative knowledge sharing, networking methods, networks, etc. Sustainability in ICT increases data and information storage, enables sorting and sharing, improves transport, uses smarter and automated processes, decreases resource use, and thereby improves overall performance. Fundamental difficulties that face ICT companies nowadays in establishing and delivering environmental, social, and economic sustainability purposes involve recognizing sustainable advancing model, identifying the most effective systems, and measuring and evaluating achievement upon those systems [83]. The organization requires a structure to assess sustainability which is compatible, positive, and appropriate to ICT companies' practices away from the data center maintenance and the obtaining of electronic merchandise [83]. If an organization does not possess a good structure, the difficulty of establishing sustainable systems rests with each company or association. This has occurred in various ways and there is a widespread lack of baseline knowledge concerning sustainable operations in the sector. This framework has become a balanced method in considering economic, environmental, and social sustainability matters in ICT and identifying the potential enrichment of innovation in sustainable ICT.

The three key components are complex structures, models, and sustainability perspectives and their strategy: environmental, social, and economic (the earth, people, and profits).

7.1. Social Impact

Adopting socially sustainable activities has an effect that goes beyond meeting individual human desires. It contributes to bringing value and profit to the company and expanding the impact of sustainability on the community. Fostering workers' work–life satisfaction increases their morale and leads to corporate growth. Supplier selection, which supports green initiatives, has a direct effect on sustainability [24,84]. Confirming that manufacturers are willing to assess the business is not the only link in the competitive supply chain. Potential customers and community still play a significant role, as every ICT company depends heavily on its clients—whether they be internal (users) or external. Increasing involvement in humanity spreads the company's sustainability influence beyond its staff, distributors, and corporate partners [83].

An organization's dedication to social development is further represented through community engagement, volunteer activities, and contributions to public programs and non-profits. For example, a company will enhance sustainability through educational campaigns that enable workers to follow sustainable behaviors, such as recycling and decreased printing. The ability to integrate awareness campaigns through the community, consumer, and supplier engagement initiatives will inspire them to do likewise.

7.2. Economic Impact

The key criteria for achieving sustainability in an ICT company are ensuring economic stability, preserving financial integrity, and allocating capital to finance sustainability programs. Having committed to the company's sustainability is just one phase in the absence of adequate funding to implement sustainable programs. In creating a business justification for sustainability policies, the opportunity to measure financial consequences such as reductions in utility bills resulting from a new energy-efficiency plan is key. Economic benefits and environmentally friendly, socially responsible policies will further promote sustainability practices. Decreasing environmental threats will benefit the company in the long run by engaging in initiatives and prevention steps. A legal and sustainable marketing and branding strategy is, therefore, critical [83]. The economic parameters are drawn from the already mentioned sustainability structures and ranking systems. Criteria to be chosen had to be applicable to both the ICT industry and one or more of the following areas of operational sustainability: operational and risk control, marketing and reputation management, remunerations, and monetary rewards.

7.3. Environmental Impact

An ICT organization's environmental management addresses the environmental effects of its goods, processes, and activities. Energy performance, water quality, pollution minimization, advancements in air conditioning, carbon emissions reduction, and environmental protection and monitoring systems are all requirements that are widely discussed by sustainable environmental evaluation approaches. The current ICT guidelines previously discussed a particular impact on environment areas such as water use and electronic waste. The original list has been extended to include: general services, business processes, data center and storage, IT agency and equipment management system (EMS), environmental regulation, environmental monitoring, and carbon control [83]. The issues discussed include implementing policies and practices that protect public wellbeing and the climate, developing an environmental performance strategy and control and monitoring policy, and openly reporting and discussing environmental impacts and attempts to reduce them.

8. Conclusions

ICT—typically, the use of Internet-based online transactions, is fast replacing the conventional approach in carrying out operations amidst mortal and brick businesses. The Internet offers many beneficial features covering broad connectivity, speed, moderate cost, and user-friendliness. With a digital network economy, e-commerce and the Internet are quickly spreading internationally, bringing several countries in the world together. Because of the Internet's power, several industries depend on adopting ICT, particularly the building industry. Naim and Lenka [85] reported that Internet usage might be a severe issue in improving a firm's operational efficiency and market reach. Many studies concluded that the investment and adequate utilization of ICT in the CI are the main techniques for enhancing productivity within the sectors.

Additionally, the government has devoted the maximum attention to improving the environment and infrastructure of ICTs adoption in the construction sector to ensure the country's rapid growth in this information era. Moreover, a report has shown that ICT is poised to become one of the key means of arousing economic growth by becoming an important sector due to its responsibility in enhancing the development of other establishments in the nation. The adoption of ICT in all divisions, particularly in the CI, will facilitate a national economic extension.

Moreover, competition in the global market is becoming more demanding and multifarious, especially for a developing nation. Hence, to compete not only includes economic liberation but also the extent to which ICT is being utilized in a nation. For example, the use of ICT (advancement in the communication) has drastically reduced both transaction and information costs. Thus, there is a need for broader dissemination to guarantee national development. For this reason, it has become pertinent

for developing countries to ensure widespread ICT in the economy to enjoy the optimum benefit from it. Therefore, instead of building production capabilities in relative isolation, decisive policies must be set up to address the failures in attaining global competitiveness. This implies that the necessary resources available in the country should be properly channeled into the worldwide market to benefit maximally from the payoffs of ICT investment.

The study identified project and site managers and quantity surveyors as the main ICT users in the Nigerian CI for the range of ICT resources. This study's functional implications would enhance the understanding of ICT in construction management practices by front-line managers and could potentially encourage the complete deployment of ICT in the industry, particularly in Nigeria, where many ICT potentials have yet to be exploited. This study also identified the antecedents of ICT use's productivity impacts as the most significant overall driver and the most critical issue contributing to the complete construction project progress. The research has significant practical ramifications, which suggest that productivity as a critical factor in building project success in satisfying stakeholders is a key instigator of expanded ICT usage.

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